US009347330B2

(12) **United States Patent**
Chuong et al.

(10) **Patent No.: US 9,347,330 B2**
(45) **Date of Patent: May 24, 2016**

(54) **FINGER SEAL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 110 days.

(21) Appl. No.: **13/730,900**

(22) Filed: **Dec. 29, 2012**

(65) **Prior Publication Data**

US 2014/0183825 A1 Jul. 3, 2014

(51) **Int. Cl.**
F16J 15/32 (2006.01)
F01D 11/00 (2006.01)
F16J 15/08 (2006.01)

(52) **U.S. Cl.**
CPC ***F01D 11/003*** (2013.01); ***F01D 11/005*** (2013.01); ***F16J 15/0887*** (2013.01); *F05D 2240/59* (2013.01); *F05D 2250/293* (2013.01); *F05D 2300/5024* (2013.01)

(58) **Field of Classification Search**
CPC .. F01D 11/003; F01D 11/005; F16J 15/0887; F05D 2250/293; F05D 2300/5024
USPC 277/650, 652
See application file for complete search history.

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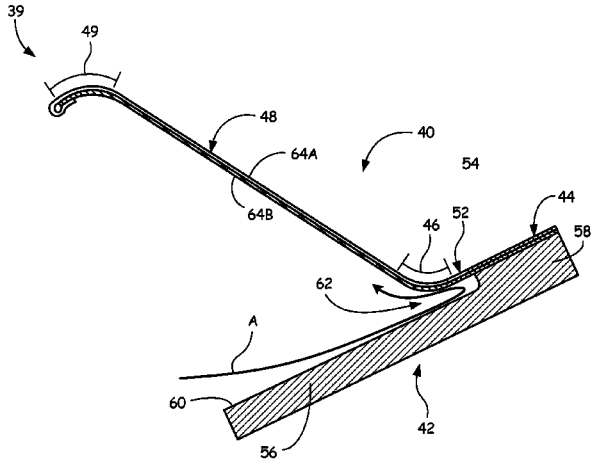
(57) **ABSTRACT**

An assembly for a gas turbine engine includes a component and a finger seal. The component has a first surface and a second surface. The first surface has an elevation that differs from an elevation of the second surface. The finger seal is connected to the first surface and extends above the second surface. The disposition of the second surface relative to the finger seal creates a cavity below a curved portion of the finger seal.

20 Claims, 4 Drawing Sheets



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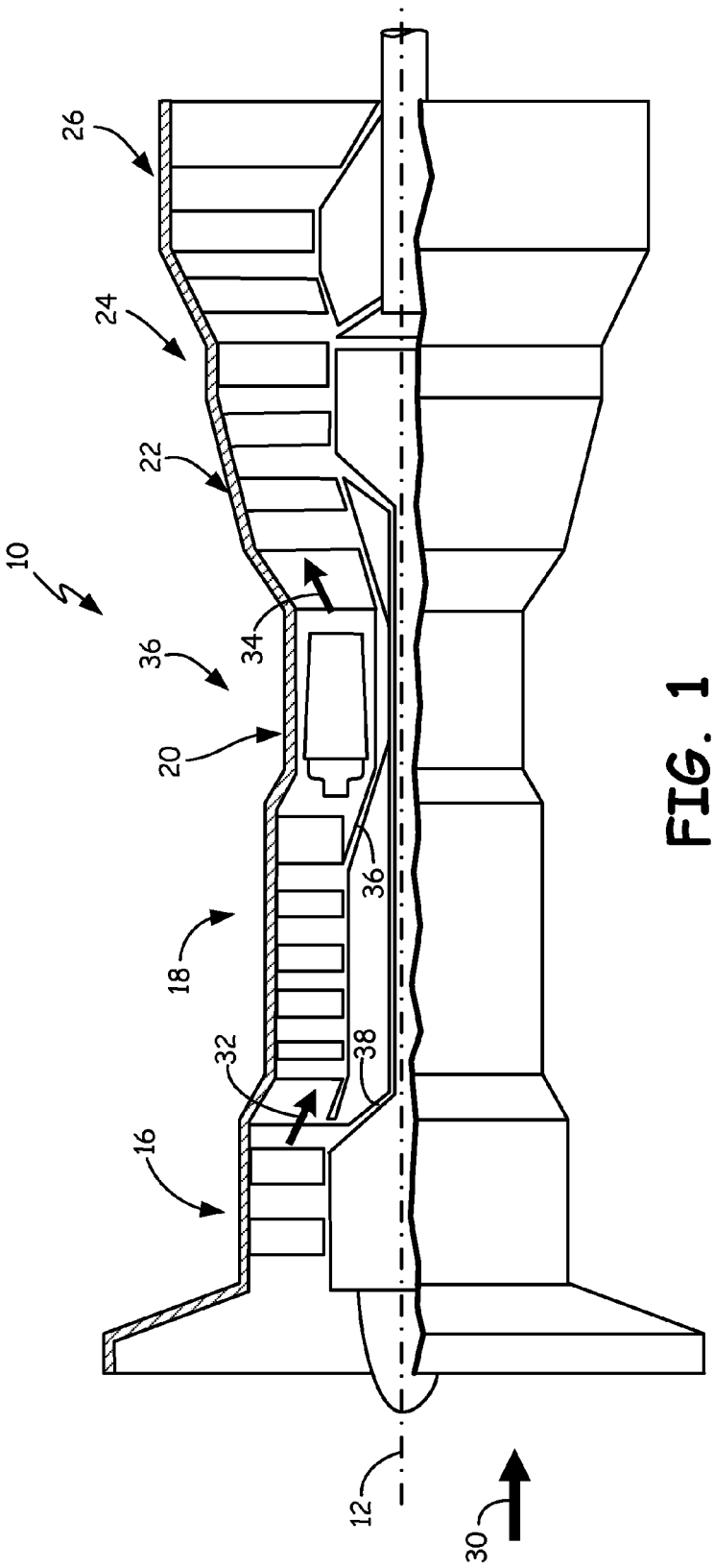

FIG. 1

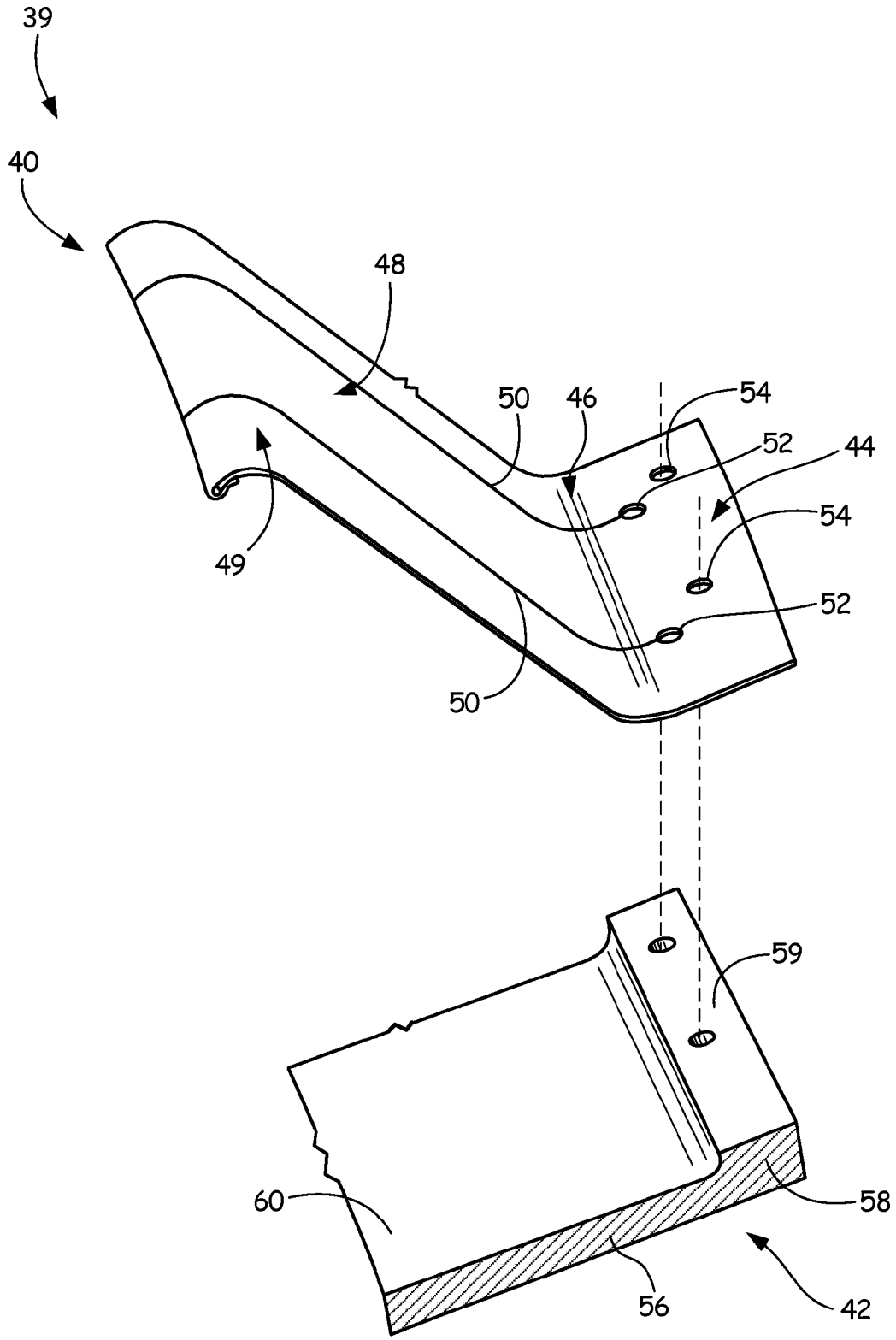

FIG. 2A

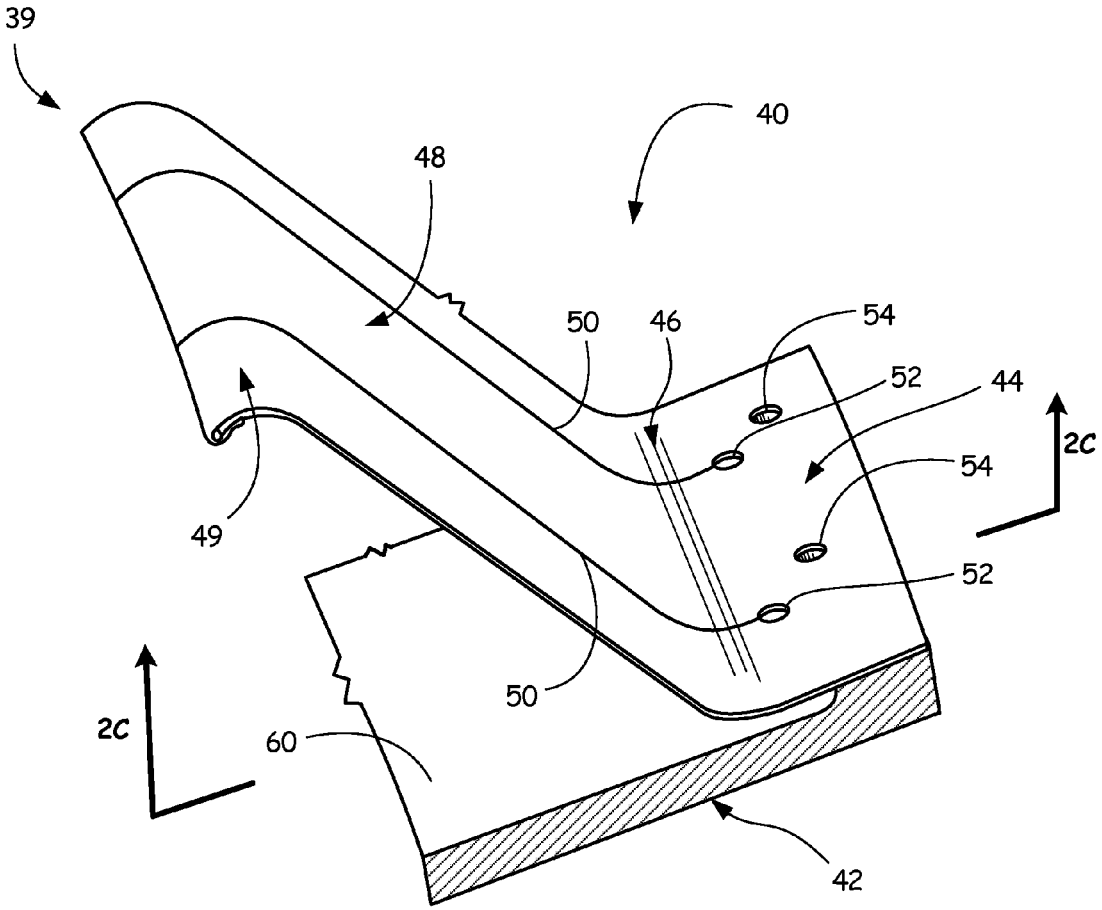

FIG. 2B

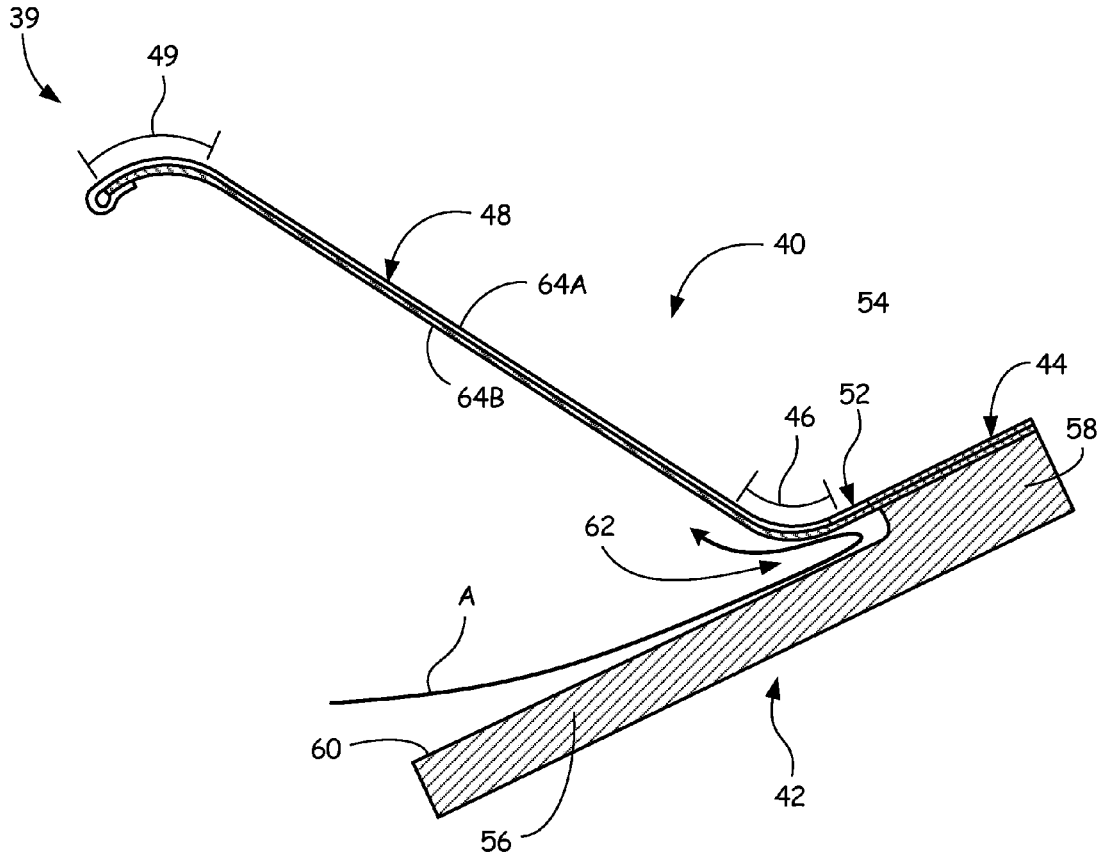

FIG. 2C

FINGER SEAL

BACKGROUND

The invention relates to gas turbine engines, and more particularly to finger seals used in gas turbine engines.

Gas turbine engines operate according to a continuous-flow, Brayton cycle. A compressor section pressurizes an ambient air stream, fuel is added and the mixture is burned in a central combustor section. The combustion products expand through a turbine section where bladed rotors convert thermal energy from the combustion products into mechanical energy for rotating one or more centrally mounted shafts. The shafts, in turn, drive the forward compressor section, thus continuing the cycle. Gas turbine engines are compact and powerful power plants, making them suitable for powering aircraft, heavy equipment, ships and electrical power generators. In power generating applications, the combustion products can also drive a separate power turbine attached to an electrical generator.

Components such as finger seals are used in gas turbine engines and act as flow discouragers and seals to seal off cavities from one another. Typically, finger seals are directly attached to components. As a result of this arrangement, heat transfers directly to the finger seal via conduction. In most instances, heat transfer via conduction is undesirable as more costly materials that perform better at higher temperatures must be used to form the finger seal.

SUMMARY

An assembly for a gas turbine engine includes a component and a finger seal. The component has a first surface and a second surface. The first surface has an elevation that differs from an elevation of the second surface. The finger seal is connected to the first surface and extends above the second surface. The disposition of the second surface relative to the finger seal creates a cavity below a curved portion of the finger seal.

An assembly for a gas turbine engine includes a component and a finger seal. The component has a raised mounting surface and a main surface. The main surface has an elevation that is staggered relative to an elevation of the raised mounting surface. The finger seal has a free end, a first curved section, and a fixed end. The fixed end is connected to the raised mounting surface and the first curved section is disposed adjacent to the fixed end and is positioned over a portion of the main surface that is adjacent the raised mounting surface.

An assembly for a gas turbine engine includes a component and a finger seal. The component has a first surface and a second surface. The first surface has an elevation that differs from an elevation of the second surface. The finger seal is connected to the first surface and extends above the second surface. A cooling air flow is passed along the second surface and along a curved portion of the finger seal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a general industrial turbine cross-section.

FIG. **2**A is an exploded perspective view of a portion of a finger seal and a portion of a component.

FIG. **2**B is a perspective view showing the finger seal mounted to the component.

FIG. **2**C is a cross-section along section **2**C-**2**C of FIG. **2**B.

DETAILED DESCRIPTION

The application discloses a staggered surface configuration on the component such that a cavity is formed adjacent a high-stress portion(s) of the finger seal. The cavity reduces conductive heat transfer to the finger seal at the high-stress portion. This configuration increases margin of safety and allows for less expensive materials to be used for the finger seal, by effectively reducing the temperature of the seal.

An exemplary industrial gas turbine engine **10** is circumferentially disposed about a central, longitudinal axis or axial engine centerline axis **12** as illustrated in FIG. **1**. The engine **10** includes in series order from front to rear, low and high pressure compressor sections **16** and **18**, a central combustor section **20** and high and low pressure turbine sections **22** and **24**. In some examples, a free turbine section **26** is disposed aft of the low pressure turbine **24**. Although illustrated with reference to an industrial gas turbine engine, this application also extends to aero engines with a fan or gear driven fan, and engines with more or fewer sections than illustrated.

As is well known in the art of gas turbines, incoming ambient air **30** becomes pressurized air **32** in the compressors **16** and **18**. Fuel mixes with the pressurized air **32** in the combustor section **20**, where it is burned to produce combustion gases **34** that expand as they flow through turbine sections **22**, **24** and power turbine **26**. Turbine sections **22** and **24** drive high and low pressure rotor shafts **36** and **38** respectively, which rotate in response to the combustion products and thus the attached compressor sections **18**, **16**. Free turbine section **26** may, for example, drive an electrical generator, pump, or gearbox (not shown).

It is understood that FIG. **1** provides a basic understanding and overview of the various sections and the basic operation of an industrial gas turbine engine. It will become apparent to those skilled in the art that the present application is applicable to all types of gas turbine engines, including those with aerospace applications.

FIG. **2**A shows an exploded assembly **39** of finger seal **40** and component **42**. FIG. **2**B shows finger seal **40** mounted to component **42**. FIG. **2**C shows a cross-section along section **2**C-**2**C of FIG. **2**B. Finger seal **40** includes fixed end portion **44**, first curved portion **46**, free end portion **48**, second curved portion **49**, slots **50**, keyholes **52**, mounting holes **54**, first ply **64**A (FIG. **2**C), and second ply **64**B (FIG. **2**C). Component **42** includes main body **56** and mounting portion **58**. Mounting portion **58** includes surface **59** (shown in FIG. **2**A). Main body **56** includes surface **60**.

In FIGS. **2**A and **2**B, component **42** and finger seal **40** are shown broken away as only a portion of component **42** and finger seal **40** is illustrated. For example, finger seal **40** can have an annular shape and be disposed so as to extend circumferentially around centerline axis **12** (FIG. **1**) of gas turbine engine **10**.

Fixed end portion **44** is adapted to be disposed directly on surface **59** of component **42** and extends to first curved portion **46**. First curved portion **46** comprises a curved section of finger seal **40** that is disposed between fixed end portion **44** and free end portion **48**. When finger seal **40** and component **42** are assembled, fixed end portion **44** is connected to mounting portion **58** and first curved portion **46** is disposed above main body **56**. First curved portion **46** additionally forms a portion of cavity **62** (FIG. **2**C). Free end portion **48** extends away from first curved portion **46** and extends to second curved portion **49**. Free end portion **48** cantilevers above main body **56** and is supported from fixed end portion **44**. Mounting holes **54** receive fasteners (not shown) to connect seal **40** to mounting portion **58** of component **42**. In other embodiments, seal **40** can be connected to component **42** by welding, brazing, adhesives, rivets, or another form of connection.

Main body **56** has a different thickness than mounting portion **58**. This can result from a depression such as a cutout

being formed in main body **56** or from mounting portion **58** being raised relative to portions of component **42** including main body **56**. As a result of the different thicknesses of main body **56** and mounting portion **58**, surface **60** of main body **56** is staggered in elevation relative to surface **59** (FIG. **2**A) of mounting portion **58**.

Cavity **62** is formed as a result of the disposition of main body **56** relative to mounting portion **58** and finger seal **40**. Cavity **62** can be the result of different thickness of main body **56** relative to mounting portion **58** in some embodiments. In other embodiments, main body **56** and mounting portion **58** may have a same thickness but are staggered relative to one another. Finger seal **40**, which extends from mounting portion **58**, is arranged above main body **56**. Cavity **62** is disposed between first curved portion **46** and surface **60**, and extends to mounting portion **58**. Cavity **62** is disposed below first curved portion **46** and keyholes **52** in a high stress area of finger seal **40**. Positioning cavity **62** between first curved portion **46** and keyholes **52** and surface **60** reduces conductive heat transfer to finger seal **40** in those areas. In one embodiment, cooling air flow A (FIG. **2**C) can be passed through cavity **62** and along first curved portion **46** to cool finger seal **40** by convective heat transfer.

Keyways **52** are positioned above cavity **62** adjacent the edge of mounting portion **58**. Slots **50** extend from keyways **52** along first curved portion **46**, free end portion **48**, and second curved portion **49**. Because the section for FIG. **2**C extends along one of the slots **50** (FIG. **2**B), only one keyway **52** is illustrated in FIG. **2**C. This keyway **52** is disposed only in first ply **64**A. Additionally, because the section taken for FIG. **2**C extends along one slot **50**, only second ply **64**B is cross-hatched in FIG. **2**C for an entire length. First ply **64**A is not cross-hatched along first curved portion **46**, free end portion **48**, and second curved portion **49**.

In the embodiment shown in FIG. **2**C, finger seal **40** utilizes two layers of plies **64**A and **64**B. Each layer of plies **64**A and **64**B is divided into a number of spaced finger elements by slots **50** that extend from keyways **52**. Slots **50** space the finger elements in order to reduce the hoop stress in finger seal **40**. Keyways **52** are circularly shaped so as not to propagate slots **50** across the entire finger seal **40**. Slots **50** create a space between the finger elements; however, this gap is sealed by the adjoining ply which is positioned such that the finger elements of each ply block any slots **50** of the adjacent ply to reduce gas leakage past finger seal **40**. Thus, second ply **64**B includes slots and keyways that are not illustrated in the FIGURES because slots and keyways of second ply **64**B are staggered in a circumferential direction relative to slots **50** and keyways **52** of first ply **64**A, and therefore, are covered by first ply **64**A in FIGS. **2**A and **2**B.

Finger seal **40** is formed of thin deflectable and formable metal such as sheet stock and has first ply **64**A disposed over second ply **64**B. First ply **64**A and second ply **64**B are connected together by overlapping first ply **64**A around second ply **64**B at second curved portion **49** at the end of finger seal **40**. First ply **64**A and second ply **64**B are additionally connected together at fixed end portion **44** by compression of fasteners (not shown) that are received in mounting holes **54**. Use of multiple laminate plies such as first ply **64**A and second ply **64**B provides for increased ability of finger seal **40** to create a seal. In other embodiments, finger seal **40** may include three or more layers or only a single layer.

The application discloses a staggered surface configuration on the component such that a cavity is formed adjacent a high-stress portion(s) of the finger seal. The cavity reduces conductive heat transfer to the finger seal at the high-stress portion. This configuration increases margin of safety and allows for less expensive materials to be used for the finger seal.

Discussion of Possible Embodiments

The following are non-exclusive descriptions of possible embodiments of the present invention.

An assembly for a gas turbine engine includes a component and a finger seal. The component has a first surface and a second surface. The first surface has an elevation that differs from an elevation of the second surface. The finger seal is connected to the first surface and extends above the second surface. The disposition of the second surface relative to the finger seal creates a cavity below a curved portion of the finger seal.

The assembly of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

the finger seal has a plurality of slots connected to keyholes, and the keyholes are positioned above the cavity;

the finger seal is fixed to the first surface and cantilevers to a free end that is disposed above the second surface;

a cooling air flow is passed along the second surface and into the cavity;

the cooling air flow passes along the curved portion of the finger seal;

the first surface is formed by a raised portion of the component; and

the second surface is recessed relative to a remainder of the component including the first surface.

An assembly for a gas turbine engine includes a component and a finger seal. The component has a raised mounting surface and a main surface. The main surface has an elevation that is staggered relative to an elevation of the raised mounting surface. The finger seal has a free end, a first curved section, and a fixed end. The fixed end is connected to the raised mounting surface and the first curved section is disposed adjacent to the fixed end and is positioned over a portion of the main surface that is adjacent the raised mounting surface.

The assembly of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

the free end and curved section of the finger seal has a plurality of slots that extend to connect to keyholes adjacent the free end, and the keyholes are positioned above the main surface;

the free end of the finger seal cantilevers to a second curved section disposed above the main surface;

a cooling air flow is passed along the main surface;

the cooling air flow passes along the curved section of the finger seal;

the staggered elevation of the main surface relative to the raised mounting surface creates an undercut below the curved section of the finger seal; and

the main surface is recessed relative to a remainder of the component including the raised mounting surface.

An assembly for a gas turbine engine includes a component and a finger seal. The component has a first surface and a second surface. The first surface has an elevation that differs from an elevation of the second surface. The finger seal is connected to the first surface and extends above the second surface. A cooling air flow is passed along the second surface and along a curved portion of the finger seal.

The assembly of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

the finger seal has a plurality of slots connected to keyholes, and the keyholes are positioned above a cavity that is formed between the second surface and the finger seal;

the second surface is recessed relative to a remainder of the component including the first surface;

the first surface is formed by a raised portion of the component; and

the finger seal is fixed to the first surface and cantilevers to a free end that is disposed above the second surface.

While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

The invention claimed is:

1. An assembly for a gas turbine engine, comprising:

a component having a main surface, a protrusion extending from the main surface, and a raised mounting surface disposed on the protrusion, wherein the main surface has an elevation that is staggered relative to an elevation of the raised mounting surface; and

a finger seal having a free end, a first curved section, and a fixed end, wherein the fixed end is connected to the raised mounting surface, the fixed end extending from the raised mounting surface such that the fixed end is offset from and generally parallel to the main surface, and wherein the first curved section is disposed adjacent the fixed end and is positioned over a portion of the main surface that is adjacent the raised mounting surface, and wherein the component has a first thickness at the main surface and a second thickness at the mounting surface, and wherein the second thickness is greater than the first thickness such that an undercut cavity is defined by the main surface and the fixed end of the finger seal, and wherein the finger seal comprises:

a first ply; and

a second ply extending along a length of the first ply, wherein the first and second plies are attached at the fixed end, and wherein the first ply is connected to the second ply at the free end by overlapping the first ply around an end of the second ply.

2. The assembly of claim **1**, wherein the free end and the first curved section of the finger seal has a plurality of slots that extend to connect to keyholes adjacent the free end, and wherein the keyholes are positioned above the main surface.

3. The assembly of claim **1**, wherein the free end of the finger seal cantilevers to a second curved section disposed above the main surface.

4. The assembly of claim **1**, wherein a cooling air flow is passed along the main surface.

5. The assembly of claim **4**, wherein the cooling air flow passes along the curved section of the finger seal.

6. The assembly of claim **1**, wherein the staggered elevation of the main surface relative to the raised mounting surface creates an undercut below the curved section of the finger seal.

7. The assembly of claim **1**, wherein the main surface is recessed relative to a remainder of the component including the raised mounting surface.

8. An assembly for a gas turbine engine, comprising:

a component having a first surface and a second surface, wherein the first surface has an elevation that differs from an elevation of the second surface; and

a finger seal connected to the first surface, the finger seal comprising:

a curved portion;

a fixed end extending from the first surface to the curved portion that is substantially parallel to and spaced from the second surface to define an undercut cavity, wherein a cooling air flow is passed along the second surface and along the curved portion of the finger seat;

a first ply; and

a second ply extending along a length of the first ply, wherein the first and second plies are fixed at the first surface, and wherein the first ply is connected to the second ply at a free end of the finger seal by overlapping the first ply around an end of the second ply.

9. The assembly of claim **8**, wherein the finger seal has a plurality of slots connected to keyholes, and wherein the keyholes are positioned above the undercut cavity.

10. The assembly of claim **8**, wherein the second surface is recessed relative to a remainder of the component including the first surface.

11. The assembly of claim **8**, wherein the first surface is formed by a raised portion of the component.

12. The assembly of claim **8**, wherein the finger seal is fixed to the first surface and cantilevers to a free end that is disposed above the second surface.

13. An assembly for a gas turbine engine, comprising:

a component having a first surface, a mounting portion that extends from the first surface, and a second surface disposed on the mounting portion, wherein the second surface is offset from the first surface; and

a finger seal connected to the second surface at a fixed end of the finger seal, the fixed end extending from the second surface to a first curved portion of the finger seal, wherein the fixed end of the finger seal is substantially parallel to the second surface, and wherein an undercut cavity is at least partially defined by the fixed end of the finger seal and the first surface.

14. The assembly of claim **13**, wherein the finger seal has a plurality of slots connected to keyholes, and wherein the keyholes are positioned above the undercut cavity.

15. The assembly of claim **13**, wherein the finger seal is fixed to the second surface and cantilevers to a free end that is spaced from the first surface.

16. The assembly of claim **13**, wherein a cooling air flow is passed along the first surface and the first curved portion of the finger seal and into the undercut cavity.

17. The assembly of claim **13**, wherein the first surface is recessed relative to a remainder of the component including the second surface.

18. The assembly of claim **13**, wherein the first surface of the component and the finger seal at least partially define a main cavity in communication with a cooling air source, and wherein the undercut cavity communicates with the main cavity at the first curved portion.

19. The assembly of claim **18**, wherein the finger seal extends at an oblique angle to the second surface to a free end of the finger seal, the free end having a second curved portion adapted to seal against a seal surface of an adjacent component.

20. The assembly of claim 19, wherein the finger seal comprises:

a first ply; and

a second ply extending along a length of the first ply, wherein the first and second plies are fixed at the second surface, and wherein the first ply is connected to the second ply at the free end of the finger seal by overlapping the first ply around an end of the second ply.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 9,347,330 B2
APPLICATION NO.	: 13/730900
DATED	: May 24, 2016
INVENTOR(S)	: Conway Chuong et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims
Col. 6, Line 15
Delete "seat"
Insert --seal--

Signed and Sealed this
Nineteenth Day of July, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office